



Passiflora cacao (Passifloraceae), a New Species from
Southern Bahia, Brazil

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ABSTRACT. *Passiflora cacao* Bernacci & M. M. Souza is described. The Passifloraceae has a limited known distribution area in southern Bahia, Brazil. This new species is not very abundant and occurs in a mountainous area associated with dense ombrophilous forest noteworthy for its great biodiversity, including many species of hummingbirds. *Passiflora cacao* is similar to *P. edulis* Sims, but it can easily be recognized by the cylindrical hypanthium and winged seeds. In addition, the flowers are usually smaller, with inner corona and outer corona series greater in number.

Key words: Atlantic forest, Bahia, Brazil, IUCN Red List, *Passiflora*, Passifloraceae.

Passiflora edulis Sims, the passion fruit, is the species in the Passifloraceae of greatest economic importance, being grown in many parts of the world (Meletti & Maia, 1999; Meletti et al., 2005; Bernacci et al., 2008). However, its close phylogenetic relationships are little known since its nearest relatives are unclear (Killip, 1938; Muschner et al., 2003; Yockteng & Nadot, 2004).

The Passifloraceae has ca. 500 to 600 described species (Escobar, 1988; Bernacci et al., 2005), but there could be 650 or even 750 species (Cronquist, 1981; Bernacci et al., 2005; Feuillet & MacDougal, 2007). The family's distribution is concentrated in the tropical regions of America and Africa, and its largest genus, *Passiflora* L., is clearly American, with

a great number of species concentrated in South America, especially in the Andes (Ocampo et al., 2007).

Morphologically, *Passiflora incarnata* L. is the species most similar to *P. edulis*, and there are even taxonomic treatments in which the taxa are considered conspecific (Killip, 1938; Bernacci et al., 2008). While *P. incarnata* is native to North America, occurring in the United States, *P. edulis* is native to South and Central America (Killip, 1938; Cervi, 1997). Possibly, because of the broad natural distribution of *P. edulis*, the species presents considerable morphological variation associated with several scientific names attributed at the species level (Killip, 1938; Cervi, 1997; Bernacci et al., 2008). However, this morphological variation does not present any pattern that can be associated with geographic distribution, and several morphological characters vary independently (Killip, 1938; Cervi, 1997; Bernacci et al., 2008).

To study the Passifloraceae of Minas Gerais, the first author, together with A. C. Cervi and collaborators, collected samples and examined material in many regions of that state. In a complementary study intended to better understand species not often collected, the authors of this article examined material from regions adjacent to the state of Bahia. Great biodiversity has been observed for several plant groups in the ombrophilous forests of southern Bahia and northern Espírito Santo (Thomas et al., 1998;

Amorim et al., 2005; Martini et al., 2007), and associated mountainous regions are also known to house a relatively high number of endemic species (Martinelli, 2007). The nearby flora of northeastern Minas Gerais is relatively little known, and through a quick assessment (Salino, 2006), new records and new species were observed, including *Passiflora boticarioana* Cervi (Cervi, 2006), which was described recently. Many forested areas in southern Bahia had been preserved from disturbance for long periods; however, with the decline of cacao agriculture, remaining forest areas are now threatened, with intensified human activity—mostly commercial wood cutting—eliminating native flora (Alger & Caldas, 1994; Martini et al., 2007).

The Serra Bonita, a mountain complex close to the southern Bahian towns of Camacan (15°25'09"S, 39°29'45"W) and Pau Brasil (15°27'51"S, 39°39'04"W), has a large altitudinal range, varying between 200 and 950 m. Located centrally within it is the Natural Heritage Private Reserve (RPPN) Serra Bonita (<<http://www.uiracu.org.br/serrabonita.html>>), and preliminary studies indicate that it has high biodiversity, including new species of plants and animals (WikiAves, 2008; Amorim & Leme, 2009; Amorim et al., 2009). In the RPPN we located a native population of *Passiflora* that is similar to, but can be clearly distinguished from, *P. edulis*. Thus, we conclude that it is a species not yet described that is related to *P. edulis* and occurs within its distribution area, although not occupying the same habitat.

Passiflora cacao Bernacci & M. M. Souza, sp. nov.

TYPE: Brazil. São Paulo: cultivated in Nova Odessa, Instituto Plantarum, 30 Nov. 2007 (fl.), L. C. Bernacci 4666 (holotype, IAC; isotype, MO). Figures 1, 2.

Haec species *Passiflorae eduli* Sims similis, sed ab ea hypanthio breviter cylindrico et seminibus alatis differt.

Herbaceous climber, glabrous, pubescent only in young portions, with tendrils; vigorous, stems ca. 2–2.7 mm diam., at the height of flowers. Stipules 7–8 mm, linear-triangular; petiole 19–45 × 1 mm, subcylindrical, with 1 pair of glands at the apex, 0.5–1 × 1–2 mm, concave, plane; blades 8–12.5 × 8.4–15 cm, membranous, sometimes pubescent along the midvein, especially on the adaxial surfaces, 3-lobed, rarely entire, rounded or obtuse at base, with serrated margin, acuminate apex; joined portion 2–3.8 cm; lobes diverging at 32°–53°, central lobe 5.9–8.5 × 2.6–4.4 cm, elliptic-ovate, lateral lobes 4–7.6 × 1.4–3.5 cm, lanceolate-ovate. Flowers solitary, 3–4 cm long, showy; pedicel 17–23 mm, articulated at 5–

8 mm from the apex; bracts 3, green, verticillate at the height of articulation, 15–22 × 9–12 mm, margin ovate, serrate or entire, apex acute, sometimes apiculate, rounded base; hypanthium 8–12 × 4–6 mm, short-cylindrical; sepals fleshy, 15–19 × 7–8 mm, with 1 awn 1–2 mm, oblong, adaxially green, pubescent, abaxially whitish green; petals subequal to sepals, membranous, white; corona multiseriate, in 8 to 10 series; filaments filiform on 3 or 4 external series, radiate, wine-purple, 8–12 mm, apex sinuous, other internal series green, intermediate ca. 2–4 mm, smaller toward the interior, the most internal more distant than the others, 3 mm, apex curved inward; operculum 2–2.5 mm, ca. 6–8 mm from the hypanthial base, membranous at the base, filamented at the apex, erect; nectariferous ring, at 2 mm from hypanthial base, to 1 mm to inconspicuous; limen 6–8 mm, adnate to androgynophore, only 1–1.5 mm free; androgynophore 12–17 × 2 mm; filaments ca. 8 × 1–1.5 mm, ca. 1 mm connate at the base; anthers 7–8 × 2 mm; ovary 4.5–6 × 3–4 mm, elliptic, densely pubescent; styles 8–11 mm, pubescent; stigma 2–3 mm, very widely to obovate depressed, 2-lobed at apex. Berry ca. 4–5.5 × 3.5–4 cm, widely ovate, with many white spots, thick rind; seeds, ca. 30 to 70, 9.2–9.5 × 8–8.2 × 1.7–1.8 mm, retuse apex, mucronate, retuse base, asymmetric, brownish, reticulated, with winged margin, radially striate, whitish aril, slightly acid.

Distribution and phenology. *Passiflora cacao* is known from two locations in southern Bahia and was observed with flowers in December and with immature fruits in March and mature fruits in September. It was cultivated in the state of São Paulo, where it was observed with flowers in November, January, and March and with mature fruits in March. As with *P. edulis*, the species can present yellow or purple fruits, and yellow fruits were observed in the material from Ituberá, Bahia (Guedes 9448, ALCB, CEPEC), and in the material cultivated in the state of São Paulo (as cultivar accessions IAC-49560 and IAC-49568). Also, purple fruits were observed in material cultivated in Ilhéus, Bahia (Viana, 2009). Beyond its restricted occurrence, the new species is not abundant, and it may not have been collected or recognized, because of its similarities to *P. edulis*, by Amorim (in Flora da RPPN Serra Bonita, Bahia, Brazil) in a recent floral survey in the area.

IUCN Red List category. Since the material was collected within a radius of ca. 200 km, in light of current knowledge and information, according to IUCN Red List criteria (2001), the species should be

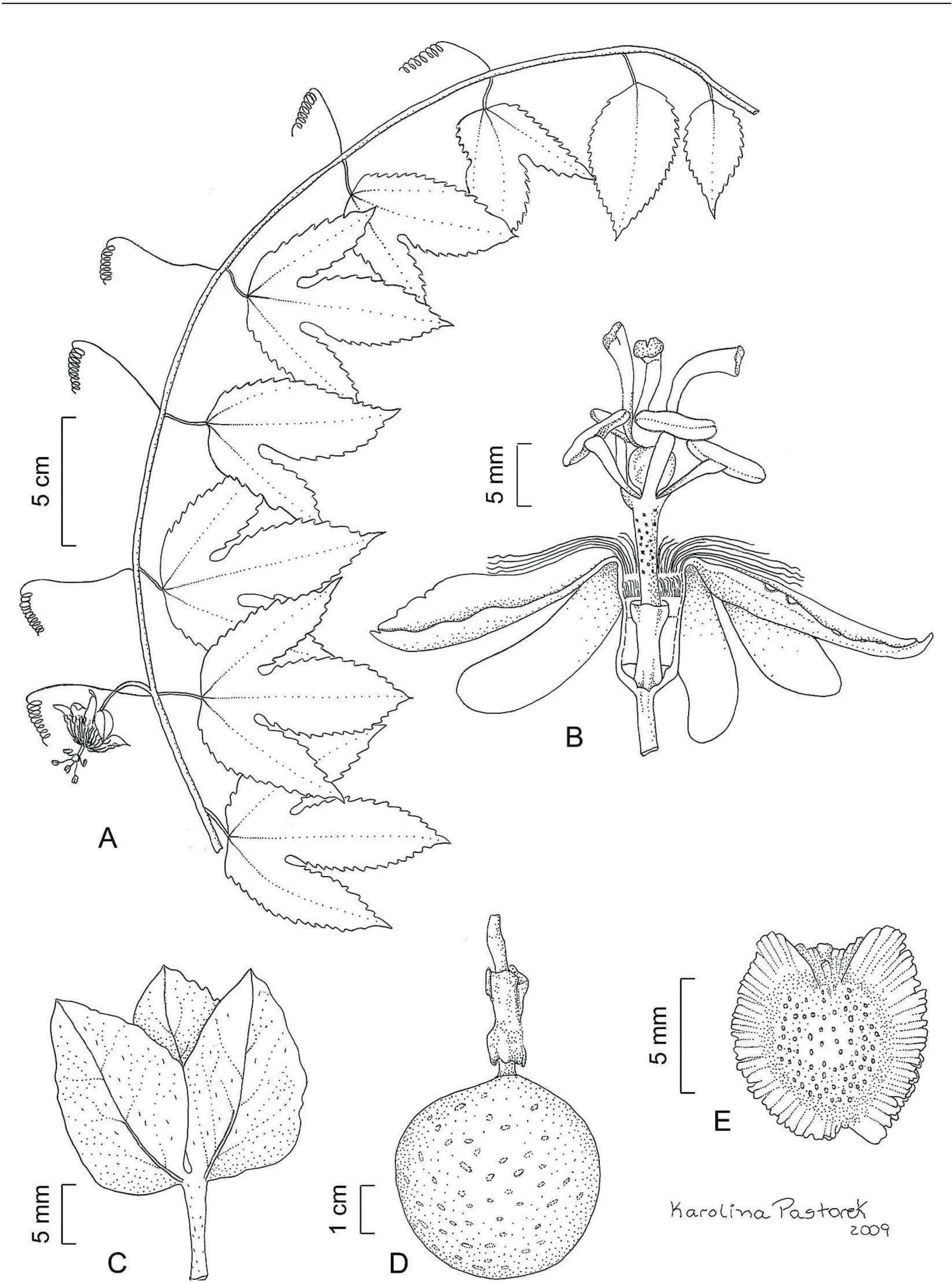


Figure 1. *Passiflora cacao* Bernacci & M. M. Souza. —A. Fertile habit. —B. Flower longitudinally dissected. —C. Peduncle highlighting the region of insertion and the bracts. —D. Fruit. —E. Seed with winged margin. Drawn from L. C. Bernacci 4492 (IAC).

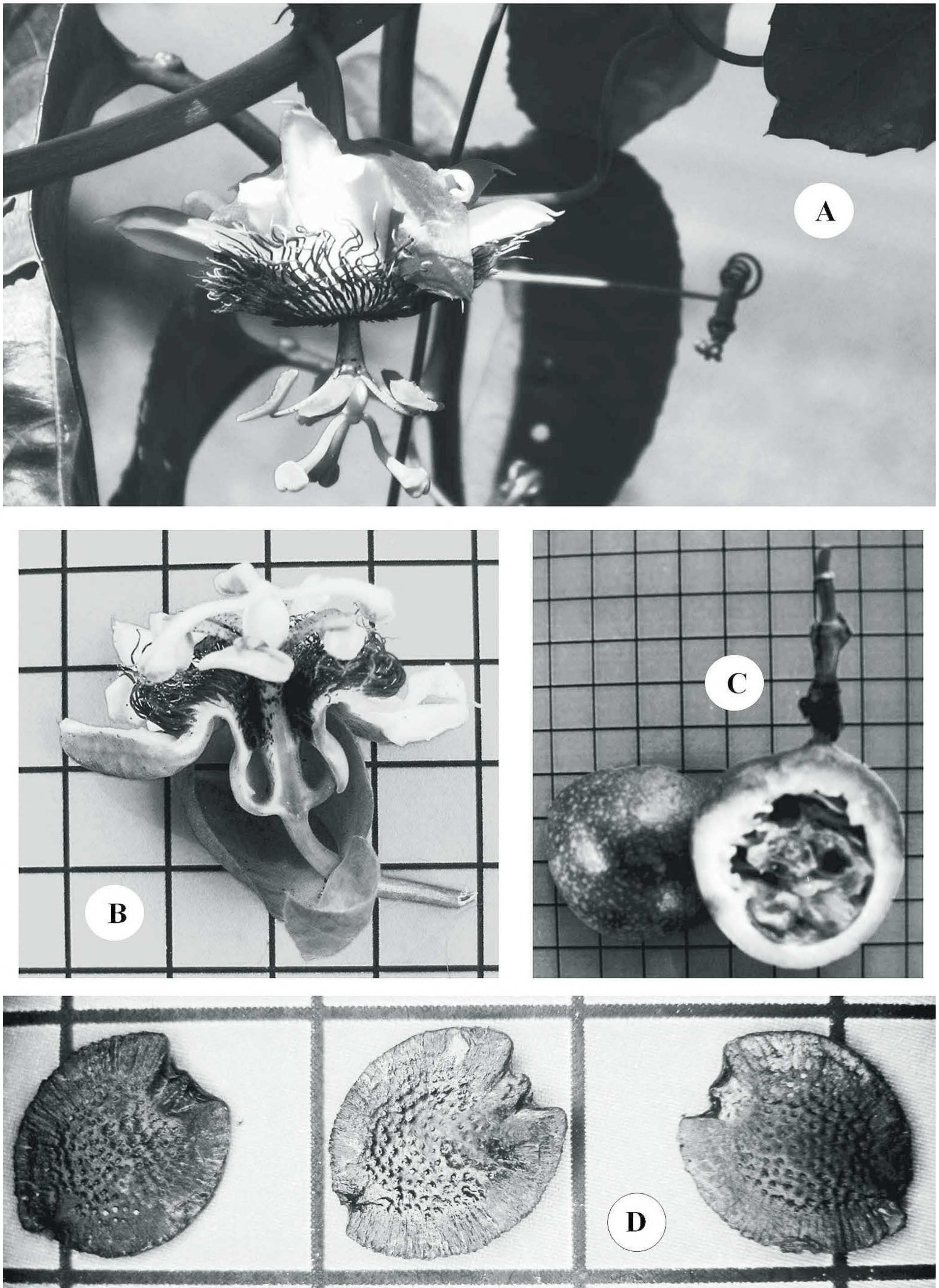


Figure 2. *Passiflora cacao* Bernacci & M. M. Souza. —A. Flower. —B. Flower longitudinally dissected. —C. Fruit longitudinally dissected. —D. Seed with winged margin. Photos of *L. C. Bernacci 4492* (IAC) by L. C. Bernacci.

considered Least Concern (LC) for the risk of extinction and additionally because it was found in a conservation unit (RPPN). Attempts at cultivation have not been successful beyond the F1 generation.

Etymology. The epithet refers to cacao (or *cacaueiro*, as known in Brazil), a plant of interest and historical importance in the agricultural economy of the southern region of Bahia (the area where this

new species of *Passiflora* naturally occurs). Although originally native to the Upper Amazon, near the Ecuadorian–Colombian border on the eastern flanks of the Andes (Cheesman, 1944, as cited in Motomayor et al., 2002), cacao has been cultivated in southern Bahia since the 17th century. The local system for growing cacao, *cabruca*, maintains native vegetation, especially large trees, and is also an important factor in maintaining the biodiversity of other groups of organisms such as birds and insects. During economic downturns in cacao production, most other economic activities in the area have resulted in continued destruction of forests and significant losses of biodiversity. The reference to cacao as the epithet in the name of this new species of *Passiflora* is made in the hopes that less aggressive techniques and more sustainable economic activities, like *cabruca*, can be maintained and developed in the region where this occurs, ensuring the maintenance of this and other species in nature, not only in areas of nature conservation but also in areas of economic development.

Discussion. Species belonging to the *Passiflora* series are close to *P. edulis* Sims, with which the new species is similar, especially in that its plants have membranous, trilobed leaves, with serrated margin, and with the width of the sepal and length of the keel identical. The length of the pedicel of *P. cacao* is within the range observed in *P. edulis* (1.6–6 cm, according to Killip [1938], Cervi [1997], and Bernacci et al. [2003]). Although the lengths do not reach the lower values observed in *P. cacao*, the lengths of the external coronal series, also radial, of *P. edulis* can be smaller, from 1 cm, or larger, to 2.5 cm (Killip, 1938; Cervi, 1997; Bernacci et al., 2003), and the lobes of the leaf's blade may diverge at smaller angles, from 44° or wider up to 120° (Bernacci et al., 2003). *Passiflora cacao*, however, can be easily distinguished by the cylindrical hypanthium and winged seeds. Additionally, *P. edulis* has a flower that is usually larger, 4–7.5 cm in diameter (Killip, 1938; Cervi, 1997; Bernacci et al., 2003), but the number of series in the corona is fewer than those seen in *P. cacao*. Besides the morphological differences observed between *P. cacao* and *P. edulis*, there are also differences in the cytological morphology of pollen, in the length of some chromosomes, in the position of microsatellites, and in the sequence of the *trnL* intron (Viana, 2009).

Passiflora incarnata, also belonging to the series *Passiflora*, is another species with which *P. cacao* has affinities, though the differences occur in a larger set of characters. *Passiflora cacao* has a larger petiole (up to 8 cm) and larger corona external series (1.5–2.5

cm). In *P. incarnata* the lateral lobes can be much longer (5–12 cm) and wider (2–5 cm), the length of the central lobe is relative to the length of the leaf blade (0.75 to 0.8), the peduncle (up to 10 cm) and flowers (sepals and petals 3.2×0.8 –1 cm and arista 2–4 mm) are larger, while the stipules (2–4 mm), the bracts ($4-8 \times 2-4$ mm, spatulate or oblong, with two glands at the base), and seeds ($4-5 \times 3-4$ mm, and not winged) are smaller (Killip, 1938; Vanderplank, 2000; Ulmer & MacDougal, 2004).

Many species of *Passiflora* have dorsal-ventral flattened seeds, of which those from *P. quadrangularis* L. (subgenus *Passiflora*, supersection *Laurifoliae* (Killip ex Cervi) Feuillet & J. M. MacDougal, series *Quadrangulares* Feuillet & J. M. MacDougal) are the most strongly depressed, being radially striate on the margin (Killip, 1938; Cervi, 1997), as described here for *P. cacao*. However, the margins of *P. quadrangularis* are not so tenuous and thin, not being winged, as they are in *P. cacao*. In *P. filamentosa* Cav. ser. *Passiflora*, the seeds are described as very flat and winged (Killip, 1938; Cervi, 1997). However, this species presents pentalobed leaves and can be easily distinguished from *P. cacao* by other aspects, such as larger flowers (8–10 cm) and peduncles (5–6 cm), larger sepals with a longer awn (to 4–5 cm and 3 mm, respectively), fewer (two) external series in the corona, these being larger (to 2–2.5 cm), and exceeding the perianth.

With the exception of *Passiflora* supersect. *Tacsonia* (Juss.) Feuillet & J. M. MacDougal—in which the hypanthium varies from cylindrical to narrowly cylindrical, and is larger than the sepals—in subgenus *Passiflora*, the hypanthium is usually campanulate, being rarely short cylindrical or narrowly cylindrical, but distinctively smaller or the same length as the sepals (Killip, 1938). *Passiflora* supersect. *Tacsonia* is characterized by its occurrence in the Andes and the presence of long, tubular flowers that are reddish, pinkish, or orangish in color, reflecting a pollination syndrome associated with visits from hummingbirds. However, molecular analysis indicates that this supersection does not correspond to a monophyletic group, it being probable that this pollination syndrome by hummingbirds may have two independent origins within this species group (Hansen et al., 2006). Species of *Passiflora* supersect. *Coccinea* Feuillet & J. M. MacDougal, such as *P. vitifolia* Kunth and *P. speciosa* Gardner, equally present red flowers and are pollinated by hummingbirds. However, the increased size of the nectariferous chamber and accumulated nectar is due rather to the diameter of

the hypanthium, as seen in *P. coccinea* Aubl. (Fischer & Leal, 2006), not because of its length.

In the species of the series *Passiflora*, the length of the hypanthium relative to the length of the sepal is between 0.17 and 0.48 (Bernacci et al., 2003), while as a rule (according to Killip [1938]) this relation is greater than 0.75 for species in section *Tacsonioides* DC. (subgenus *Passiflora*, supersection *Stipulata* Feuillet & J. M. MacDougal, which, however, includes only species with broad, sheetlike, and strongly asymmetric stipules [Feuillet & MacDougal, 2003]). *Passiflora luetzelburgii* Harms, which has a tubular hypanthium and linear stipules (Vitta & Bernacci, 2004), was included in the subgenus *Tacsonioides* (DC.) Killip (Killip, 1938) but is included now in the series *Setaceae* Killip ex Cervi (which typically has species with few series in the corona) of the section *Passiflora* (Ulmer & MacDougal, 2004). *Passiflora luetzelburgii* clashed with the other species in section *Tacsonioides* by stipule characteristics. *Passiflora trintae* Sacco (1968) and *P. farneyi* Pessoa & Cervi (1992) are species accepted for the series *Passiflora* and were recently described. *Passiflora caatingae* L. K. Escobar (1989) was synonymized to *P. trintae* (Cervi, 1995). Including those species previously attributed to *Passiflora* ser. *Serratifoliae* Killip ex Cervi, a total of 13 species have been accepted within *Passiflora* ser. *Passiflora* (MacDougal & Feuillet, 2004; Ulmer & MacDougal, 2004). Therefore, with the description of *P. cacao*, 14 species of the series *Passiflora* are now recognized, of which the majority, nine species, occur natively in Brazil. In all of these, with the exception of *P. recurva* Mast., the margin of the leaf blade varies from serrated to subentire and is only entire in *P. recurva*. The blade margins may sometimes vary within the same species, as in *P. cincinnata* Mast., in which it varies from serrate to crenate-serrate and subentire.

Passiflora trintae has red flowers and an elongated hypanthium (cylindrical and campanulate in shape), which are uncommon characteristics for its series *Passiflora* but similar to *P. luetzelburgii* and *P. racemosa* Brot. (supersection *Stipulata*) in presenting a cylindrical hypanthium and equally red or pinkish-reddish flowers (Killip, 1938; Vitta & Bernacci, 2004). Such characteristics indicate the possibility of pollination by hummingbirds, but these traits could have evolved independently. It is worth highlighting that where *P. cacao* occurs there are reports of many species of hummingbirds (cf. WikiAves, 2008). The elongated hypanthium of the new species could be an indication of its pollination by hummingbirds, although its flowers lack red coloration. Such species as *P. cacao* raise interesting questions about floral

biology and phylogenetic relationships, which merit further investigation.

Paratypes. BRAZIL. **Bahia:** Ituberá, Assentamento Lucas Dantas, litoral sul, mata ciliar, 13°43'S, 39°08'W, 3 Sep. 2001 (fr.), M. L. Guedes, D. L. Santana, D. M. Loureiro & L. J. Alves 9448 (ALCB, CEPEC); Camacan, RPPN Serra Bonita, Mata Atlântica, 10 Dec. 2004 (fl.), L. C. Bernacci, M. M. Souza, N. E. Pereira, A. S. Maia & V. O. Becker 3898 (IAC); 15°23'01.2"S, 39°34'06.9"W, 10 Dec. 2004 (fl.), L. C. Bernacci, M. M. Souza, N. E. Pereira, A. S. Maia & V. O. Becker 3900 (IAC), 7 Mar. 2006 (immature fr.), R. Tsuji, L. C. Bernacci & E. F. Souto 1188 (HPL, IAC). **São Paulo:** cultivated at Nova Odessa, Instituto Plantarum, 19 Jan. 2006 (fl.), L. C. Bernacci 4105 (IAC, UPCB); 30 Mar. 2007 (fl.), L. C. Bernacci 4405 (IAC); 10 Mar. 2008 (fl./fr.), L. C. Bernacci 4492 (IAC); (fl.), L. C. Bernacci 4494 (IAC, K); 18 Mar. 2008 (fl./fr.), L. C. Bernacci 4500 (IAC, RB); 6 Mar. 2009 (fl.), L. C. Bernacci 4677 (HUEFS, IAC).

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